Blockchain-based Supply Chain System

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ABSTRACT

In today's world, blockchain-based systems are in demand across various industries, especially in transportation and supply chain, because of its secure, trusted, and decentralized network as well as more efficient than the traditional methods. However, the traditional ways these days are facing a lot of issues and challenges because of the complex and less secure network. Blockchain network integration overcomes the problems faced by traditional methods across industries. The Blockchain integrated network provides benefits such as a reduction in cost, scalability, improve efficiency by connecting the links between the flows, increase Transparency, the trace of the product. Although the blockchain-based systems provide various benefits, due to lack of knowledge about this technology, the implementation rate is low. In this work, it highlights the distinction between the traditional transportation and supply chain as well as Blockchain network-based transportation and supply chain and the benefits of implementing Blockchain in different sectors such as health care, insurance, food industry, retail. This work highlights the issues and challenges faced by the industries, by using the traditional methods as well as the solutions to the problems provided by the blockchain network-based systems to those industries. This work helps the people to understand the benefits of blockchain network-based systems in their respective industries as well as execute it to improve the Transparency, efficiency, and security of altogether system.

Keywords : Blockchain, Industries, Supply Chain, Decentralized, Secure, Transparency, Scalability, Network, Issues, Efficiency.

I. INTRODUCTION

Blockchain technology defined as the technology that plays as a role of distributed ledger in which transactions made digitally, and at the same time, these transactions are recorded, verified, and validated throughout the network of nodes without the approval of the central authority.

The Blockchain is a yet ingenious way of passing information from one point to another point in an automatic and encrypted manner. One party to a transaction initiates the process by creating a block. Thousands verify this block, perhaps millions of distributed computers work around the net to verify that particular block. Then this block is added to a chain, stored across the network, creating not just a unique record but with a unique history. When a single record is falsified, then it would mean falsifying the entire chain in millions of instances. That is virtually impossible. Several cryptocurrencies and networks like Bitcoin and Ethereum use this model for monetary transactions, but it also has other use cases.

The complexness of supply chains, with their extensive spread networks of different entities, includes secret elements for both supplier, manufacturer, and consumer, which raise questions

about the monitoring of the supply chains many layers. These layers might contain socially and ethically irregular undertakings, such as misuse of natural and human recourses, leaving ecological footprints, handout to waste from production and transportation. In most cases, these factors are hide due to either or both lack of Transparency in the supply chains. With the blockchain network-based systems, it is easy, transparent, and very secure to keep track of the entire supply chain transportation network [4]. Any irregular activity can immediately track down. Thus, we are motivated to develop a software-based blockchain that can solve major issues and easily implemented in small- and large-scale businesses.

II. LITERATURE REVIEW

The technology behind bitcoin can use in many different industries. Blockchain technology integrated with any industry doesn't require trust, which promises efficiency, security, and Transparency. Blockchain, combined with the supply chain industry, can change and benefit how the supply chain works. Companies like Walmart and IBM have implemented blockchain technology into their supply chain network to increase food safety. Amid of 2017 in the US, there was a food outbreak. The whole process of tracking the source of the farm in Mexico took many weeks. During this track down, lives were at risk. Retailer A wouldn't want Retailer B to see how much quantity and at how much rate it was buying the products. In the traditional supply chain system, it becomes challenging to maintain original data. What if a retailer orders 20 packs of food, but the supplier delivers only 15. In this case, a retailer's database will show the order of 15 packages, and the supplier's system may show 20. As each entity is maintaining an individual database, the data might get tampered by any entity. But with an integrated blockchain supply chain network makes it quite easy to track the source of food, retailers, distributors, importers, and farms. Blockchain represents a new way of a shared database,

in which control is shared between different organizations, which is helpful when those organizations don't necessarily need to trust. In the blockchain network to before changing the database, it first has to be approved by everyone in the system. One individual wouldn't be able to update the changes. Every change in the database is associated with cryptographic has. Hashes are a short representation of data. Changing even a single value of data will give a completely different hash value. Every time a new data is added, the hash value is calculated on new data along with the previous hash. Since each hash value is built on the previous one, the information forms a change, and making a change to any value will lead to termination of the operation. There is an involvement of a digital signature that makes sure only authorized; people can change data and a separate record of all individual activity in case of wrongdoing. Ever peer involved in the operation has their copy to check the rules, hashes, and signature. Using this technology, the tracking of food origin would take just a few seconds. Blockchain-based supply chain network gives rise to automation such as stock order can be placed automatically when the stock is running low at the retailer, etc. Blockchain eliminates or reduces different checks involved in the traditional supply chain system, which requires trust. Implementing Blockchain can help increase customer trust and Transparency in the order. Blockchain technology can be applied in small as well as a vast supply chain network.

While most great utilization of Blockchain is in cryptocurrency, the Bitcoin has other advanced applications and used for any trades, contracts, and installments [5,6]. Since each ex-change is recorded on a square and over different duplicates of the appropriated records over numerous hubs, it is very straightforward. Furthermore, it is exceptionally secure as each square connects to the one preceding it and after it [6]. There is not one focal expert over the Blockchain, and it is, to a high degree, productive and

versatile. Eventually, Blockchain can build the productivity and straightforwardness of supply chains and emphatically affect everything from warehousing to conveyance to installment [5]. The hierarchy of leadership is fundamental for some things, and Blockchain has the levels of leadership worked in.

Since blockchains consider an exchange of assets anyplace on the planet without the utilization of a conventional bank, it is hugely advantageous for a globalized store network [7]. In the sustenance business, it is common to have reliable records to follow every item to its source [8,9]. In this way, Walmart utilizes the Blockchain to monitor its poultry it sources from China and the blockchain records where each bit of meat originated from, prepared, put away, and its offer by-date [8,9]. Unilever, Nestle, Tyson, and Dole likewise utilize Blockchain for comparative purposes. BHP Billiton (the world's most prominent mining firm) declared that it would utilize the Blockchain for more credible track record information through the mining procedure with its sellers, enabling the organization to have more successful correspondence with its partners [10,11]. The straightforwardness of Blockchain is likewise vital to allow customers to know they are supporting organizations that share similar estimations of natural stewardship and easy assembling [12]. It is the task Provenance would like to furnish with its blockchain record of straightforwardness. Jewel goliath De Beers utilizes blockchain innovation to track stones from the point they are disapproved straight up to the moment they bought by buyers [9]. Thus, the organization maintains a strategic distance from 'struggle' or 'blood precious stones' and guarantees real deals to the purchasers. There are a few production networks new businesses, for example, Cloud Logistics, who saw a chance to give blockchain-empowered inventory network answers for enhanced efficiencies and lesser costs for the enormous store network industry [8,9]. More organizations surely go along with them as they understand the potential and interest in blockchain-

empowered answers for change in the SCM and logistics industry.

Blockchain innovation is a database structure first designed to deal with exchanges in the Bitcoin currency [13,14]. Blockchain description made by Nikolai Hampton (2016) reiterated that physical books also viewed as a blockchain, where each page contains roughly ten minutes of exchanges in Bitcoin cash. Once a page is topped off with new exchanges, it is time-stamped, marked with a one of a kind serial number, and stuck into the book. Similarly, the pages speak to squares also;, the serial numbers speak to the connection between the squares [12]. The serial number is a result of the exchanges on that page, and the serial quantities of nearby pages are bolted together through a numerical capacity, shaping a robust chain of pages. That makes it challenging to change one of the exchanges without adjusting the serial number of that page and thus terminating the connection between that page and the accompanying page [15]. Blockchain innovation viewed as a potential method to improve the security and cost adequacy of logistics exchange [16]. Moreover, blockchain innovation is utilized to build up mix over the web and comprehended as a many-to-numerous mix show, sent in general society cloud to direct anchored exchanges quickly and with ease [12]. To build up a clear understanding of Blockchain, outline standards, and functionalities, the present investigation is grounded in a writing survey and meetings with universal specialists in blockchain innovation.

III. REQUIREMENTS ANALYSIS

Requirement analysis encompasses those tasks that our project does. Our application meets all the functional requirements and non-functional requirements, which make the project secure, and the performance of the project is spiked. It enables the project to enhance the users' experience.

A. Functional Requirements

Tokenization

It is one of the most important things you have to understand when talking about Blockchain. Also, most of us associate with Tokens things like speculative coins, ICOs, and such things, but tokens are much more than this. Tokens allow you to create digital representations for goods, services, or rights. They can be compatible or non-compatible depending on goods and services. Tokens can give you authorization to information about the product they represent, grant you some explicit usage rights, or depict the ownership of goods. These operations are highly appropriate for all digitization of real-world goods use cases because this allows trust and values to exchange between different parties without the need for a central intermediary.

Data security and privacy

These are critical requirements, especially for business use. There are two main consequences of Blockchain. The first is that it must be feasible to grant explicit data access rights to distinct users or roles. That is very significant because, in a public chain like Bitcoin, all data within a block is precise by everyone. The second issue is acquiescence with data privacy regulation. In Countries like Europe, do have a very tough data privacy regulation GDPR(General Data Protection Regulation). So people are facing issues like, for instance, that there is a right to be forgotten within the GDPR or the essential to have a data processing contract with the data provider, which could be a big hurdle in a decentralized system.

Decentralized data storage

It is an essential requirement of a distributed system. It must be possible to handle transactions and data storage efficiently. Sure, if decentralized data storage is your sole requirement, there would be better solutions than Blockchain that solve that problem. However, the ability to manage data in a decentralized, distributed way is a fundamental requirement.

Immutability

It is the property most associated with Blockchain. Immutability is the foundational requirement for digitally exchanging value. This requirement is not solvable with conventional internet technology because all digital data can be effortlessly copied and changed. If two accounts exchange knowledge, for instance, by mail, there is a copy of this mail-in everyone's mailbox. The same is for data, traded between two or more systems. The only method to solve that problem without Blockchain is by relying on a central intermediary who holds the correct version of the data. Based on the Consensus mechanism, Blockchain can solve that problem by technology.

Permanent availability of data

It is the last core necessity of Blockchain solutions. The ledger never forgets anything — which could be a problem in aspects of GDPR compliance; it is an essential feature of blockchain technology. Primarily when Blockchain is used to express real contracts, and their data, immutability, and permanent availability are crucial requirements, especially from a legal and regulatory point of view.

B. Non - Functional Requirements

UX/UI:

It's also significant from a user experience perspective. The first impression is very relevant for a new user. Launching a platform and muddling it with Blockchain associated jargon is sure to put off the majority of users. However, dumbing it down may reduce the "cool" factor or the visibility of the critical benefits of Blockchain, which distinguish your application from the non-Blockchain competition.

Scalability

Users want to know they are not being tied down to anything, and they can revert to the non-digital world at a time of their selection. Selecting the right underlying platform (or choosing to roll your own) is necessary for this.

Development Operations

Projects such as Hyperledger Cello are aiming to make Blockchain network administrators more manageable. However, It was still challenging to arrange a "production" Hyperledger Fabric cluster, and there is a lot of hand-operated steps to get Hyperledger Composer running on it. It takes time to combine these things and improve the DevOps experience, so until then, allocate the right amount of time to provisioning and automating cluster deployment.

We have used the Ethereum network, which is a public blockchain for automating smart contracts and making efficient transactions. It has cryptocurrency for transaction called as ether.

Enterprise blockchain technology can transform the supply chain with these three use cases:

· Traceability

· Transparency

· Tradeability

Traceability improves operational efficiency by mapping and visualizing enterprise supply chains. A growing number of consumers demand sourcing information about the products they buy. Blockchain helps organizations understand their supply chain and engage consumers with real, verifiable, and immutable data.

Transparency builds trust by capturing key data points, such as certifications and claims, and then provides open access to this data publicly. Once registered on the Ethereum blockchain, it's authenticity can be verified by third-party attestors.

The information can be updated and validated in real-time.

Tradeability is a unique blockchain offering that redefines the conventional marketplace concept. Using Blockchain, one may "tokenize" an asset by splitting an object into shares that digitally represent ownership. Similar to how a stock exchange allows trading of a company's shares, this fractional ownership allows the tokens to represent the value of a shareholder's stake of a given object. These tokens are tradeable, and users can transfer ownership without the physical asset changing hands.

Managing Stakeholders

There is a susceptibility when selling the benefits of a Blockchain application to oversell the interests of governance. Rationally, the governance stakeholders (e.g., police, government, auditors) obtain the most perks from being able to pursue what everyone is doing and use it to control or check compliance. It is essential, but other stakeholders need the incentive to participate in with the network; otherwise, there may be no users and no transactions to control or check. Then there is the problem of convincing all the stakeholders to get involved so you can do business analysis and requirements gathering. The modeling and smart contract definitions require a perception of the business domains of all the diverse kinds of stakeholders.

The critical success of Blockchain is that it can enable business and collaboration between organizations that have never met. It attracts many organizations during the lifetime of the platform. However, one organization needs to take the initial step, see the value, and build the platform for everyone else to use.
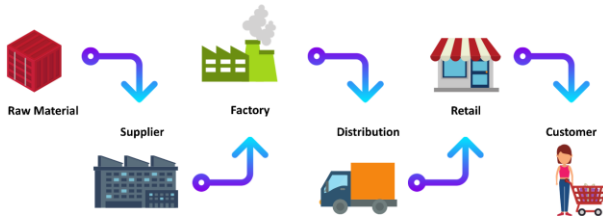
C. Software Requirements

· Operating System: - Windows/ Mac/ Linux

· Web browser

D. Hardware Requirements

· Any computer

· Minimum 2 GB RAM

IV. PROJECT DESIGN

A. The traditional supply chain system

Here, an additional occasion for order gets created for each application where the order gets entered. Orders are manually entered between applications, increasing the possibility of errors and missing information.

This problem is further irritating when a single order is split down into sub-consignment or when deface items need to be returned, making tracing a purchase through the traditional chain extraordinarily complicated and time-consuming.

B. The blockchain-based system in supply chain
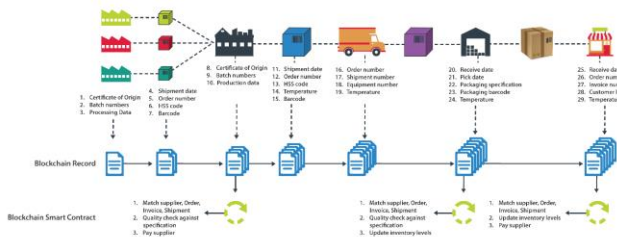
The blockchain-based supply chain system

source: https://resolvesp.com/blockchains-supply-chains-part-ii/

Here, the blockchain-based system is implemented in the supply chain and shared by all entities in the supply chain. Blockchain technology removes redundancy by having all the information available transparently. Any additional information gets added to the original entry of the data to the Blockchain. For

example, the tracking number can be added to the entry of the order in the Blockchain.

Blockchain comes after the cloud uprising, and many organizations will not need to invest in expensive hardware to start using the blockchain-based system right away.

C. Project Architecture
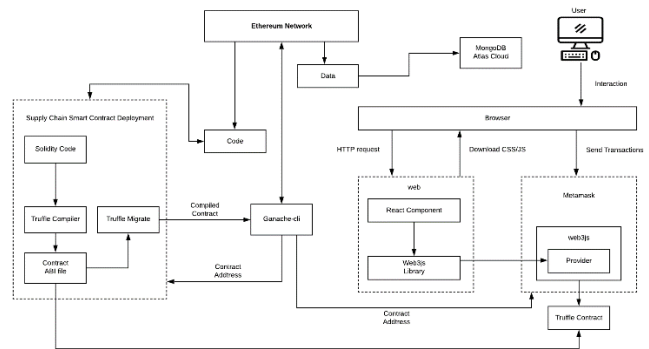
D. Sequence Diagram
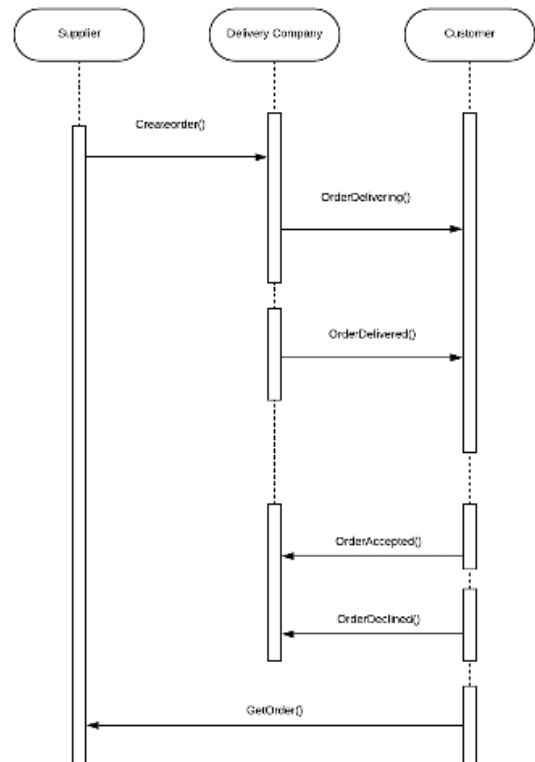
V. TECHNOLOGIES USED

We have been using numerous online platforms to communicate and to ease the work of our primary

project development. Other may also include an online project management tool introduced by the Project instructors and supervisors.

A. Tools used

· GitHub for code sharing

· Figma for UX/UI prototyping

· MongoDB for backend database

· Ganache Wallet for testing purpose wallet

B. Programming languages used

· Javascript (Frontend)

· HTML/CSS (Frontend)

· Solidity (Smart Contracts)

· Node.js (Backend)

VI. RESULT

Steps for Execution of Decentralized application (Dapp):

1. Open the Ganache command-line interface.
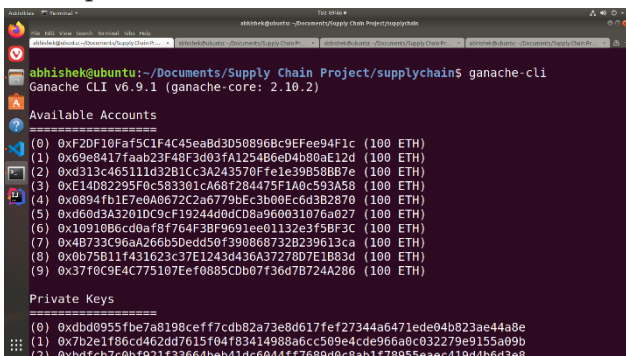
Previously known as **Testrpc**, is a virtual blockchain which sets up 10 default Etheruem addresses, complete with private keys and all, and pre-loads them with 100 simulated Ether each. There is no "mining" per-se with Ganache - instead, it immediately confirms any transaction is coming it's way. We are going to use these Ethereum addresses and their private keys to test our blockchain network.

2. Copy these Ethereum addresses and private keys to a text file for using it further for transactions.
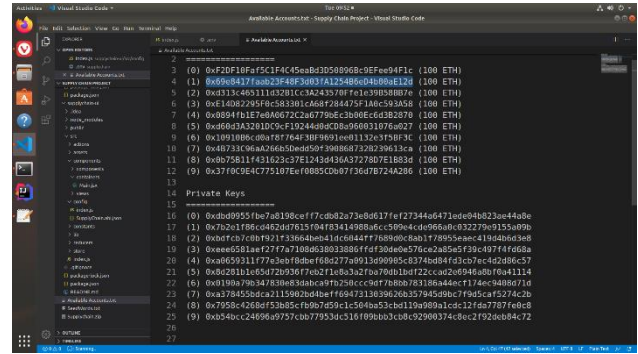
3. Use Truffle to test ➔ build ➔ migrate smart contracts for the supply chain.
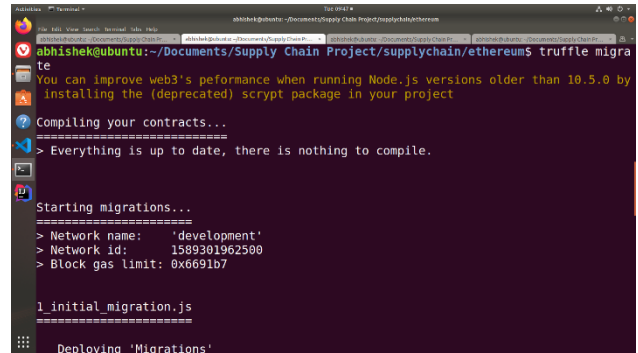
Truffle is a development environment, testing framework, and deployment pipeline for Ethereum dapps — or any blockchain using the EVM. This section breaks down what exactly this means. *For the sake of simplicity, we will refer to Ethereum (ETH) only, and not "Any EVM blockchain," as the Ethereum (ETH) mainnet is Truffle's main target production blockchain.* Truffle is operated in the Terminal, and as such, has a range of handy commands for us to use at different stages of developing a dapp.

**4.** After migration of the smart contract address will appear on the Terminal.
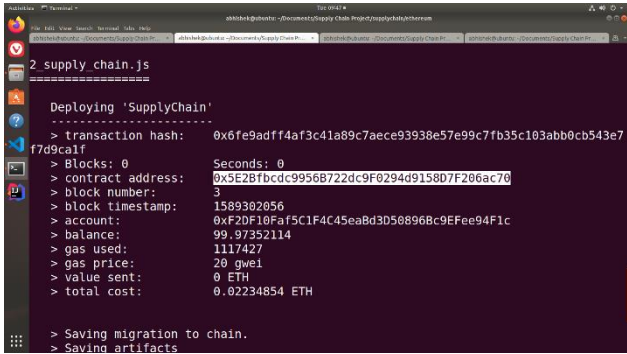
5. Copy this deployed contract address and paste it to
- **.env** file which is inside backend part
- **Index.js** file, which has .env file processes and react-router export methods.
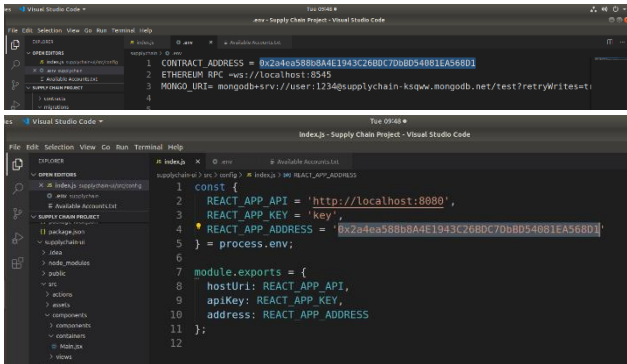
6. Start backend by nodemon for default port **8080**
nodemon is a tool that helps develop node.js based applications by automatically restarting the node application when file changes in the directory are detected. It is compatible with an **express framework** that is used in the project.
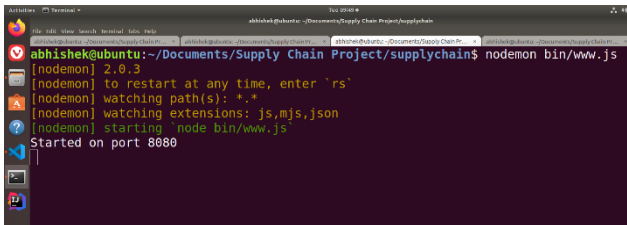
7. Start frontend by React script "Start."
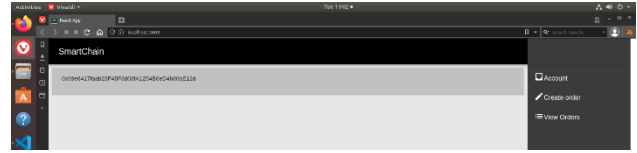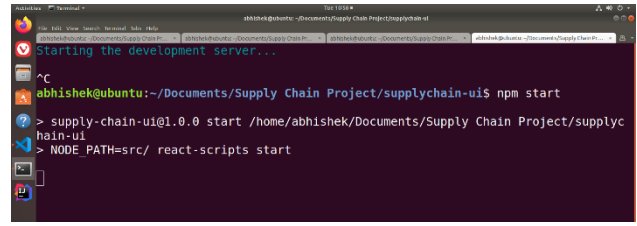
So the actual dapp will start inside a default browser with a wallet address.
By default, the react frontend will start on 3000 port.

8. Import 1 private key from **step 2** to web3 Provider. In this case, the Provider is **Metamask.**
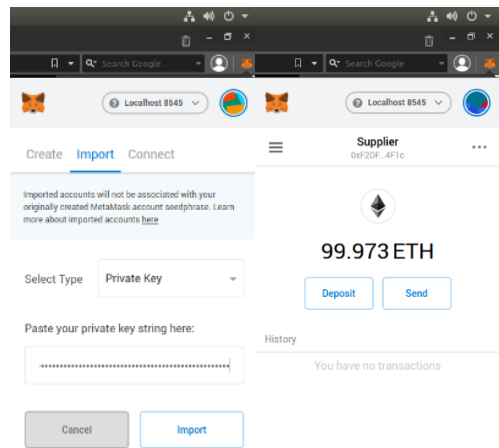
The web3 Provider By design, web3 looks for a web3 provider — a blockchain client or light node running with the capabilities to handle contract communication and make transactions on an Ethereum blockchain. This Provider will vary depending on your preferred plugin or device (Metamask, Cipher, a full go-Ethereum node, etc.).
For development purposes, web3 will be communicating with our Ganache or Truffle Develop blockchain — whichever one you opt to use for testing.

So when it comes to testing your dapp on *a public testnet* (Ropsten, Rinkeby, etc.), followed by a mainnet launch, your web3 Provider must be running that same network in order to access the contracts.
For Ganache testnet is run on 8545 port. Hence, it is named as localnet:8545 inside Metamask.

9. Assume, an imported private key is for supplier's Ethereum address with testing ethers.
So, now in browsers GUI, There are 3 options.

1. Account

2. Create Order

3. Orders
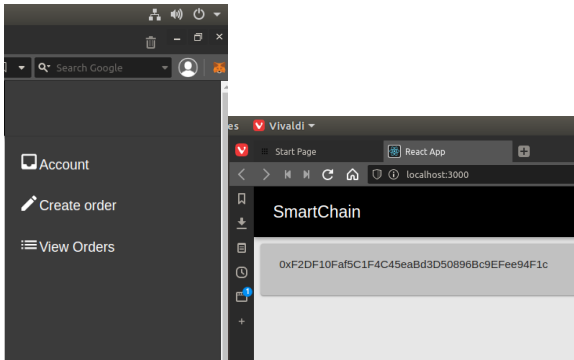
On Account, the Ethereum address will be shown for active Account on Metamask.

10. Go to create order and create a first order with:
Title, Description, Ethereum addresses of delivery company and customer.

11. There will be a confirmation pop up from Metamask with gas required for a transaction, confirm it with changes required as per transaction.

Gas is a fraction of an Ethereum token and is used by the contract to pay the miners securing that transaction on the Blockchain for their efforts. An appropriate amount of gas must be used to pay for the transaction; if the amount of gas is too low, the

transaction does not occur since miners do not receive enough compensation and abandon the job. Using gas low and high limits, developers can make sure that their smart contracts run reliably over the network. This is done by paying the miners enough compensation while not losing the extra gas they pay for the transaction that would otherwise be lost to the miners after the transaction is secured.
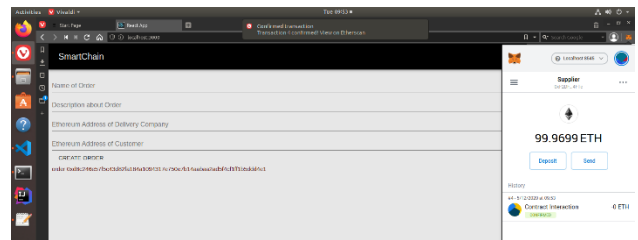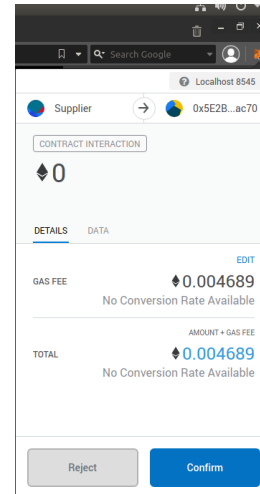
12. after the creation of orders, check Orders from GUI. Recently created orders get stored on this ribbon. Every order has its status index starting from 0.
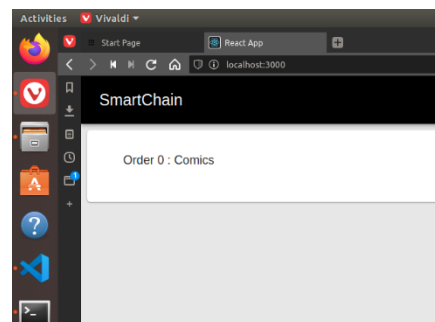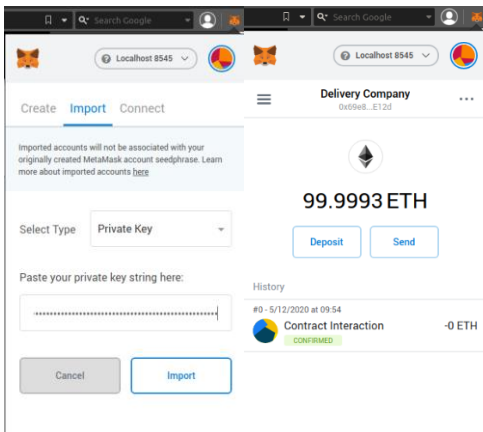
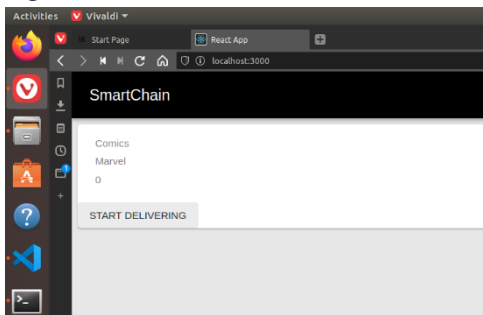**13.** Also, the same data goes to a cloud with MongoDB atlas
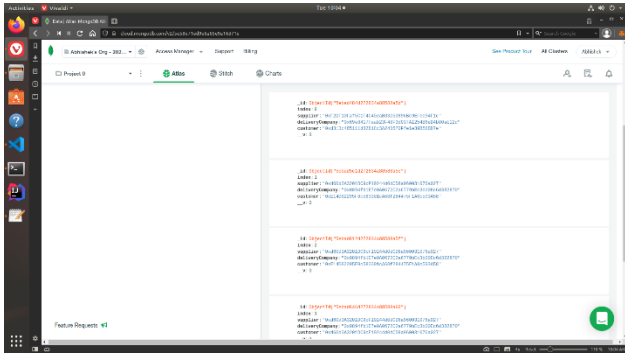
A collection of created orders can be used for further delivery of an order.

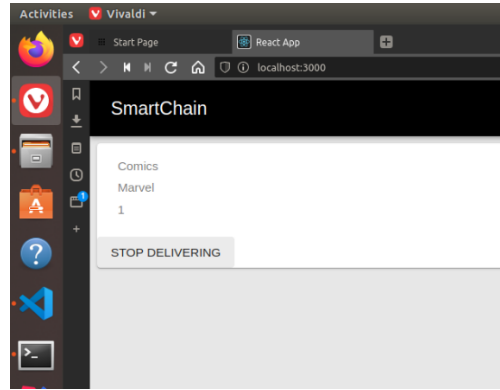**14.** Now, Import Delivery Company's private key to Metamask and go to Orders.

15. From a list of orders, select an order and click start delivering.

16. The same procedure from **step 11** is required for this transaction.

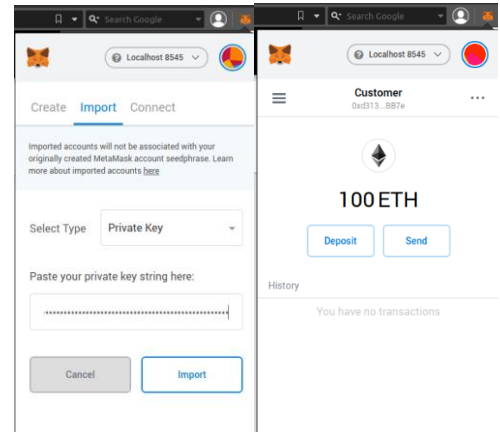**17.** After the transaction, click on Orders, and see the status of an order.
It is changed from 0 ➔ 1.

18. Now, click on stop delivering, which is available below the status of an order.

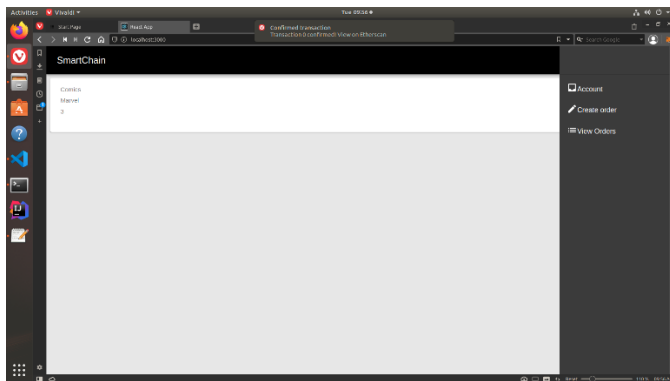Click on it and follow the procedure from **step 11**.

19. Now, Import the Customer's private key to Metamask and go to Orders.

20. From a list of orders, select an order and click on accept. If the customer does not accept the order, it means that the order is rejected by the customer.
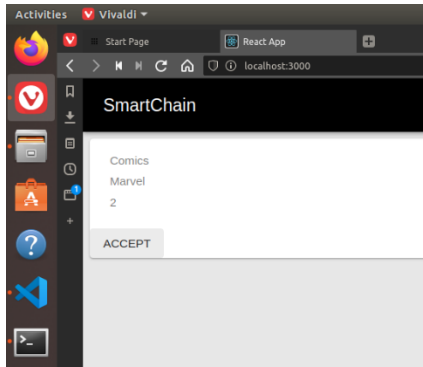
Final Output

VII. CONCLUSION

This work highlights the distinction between the traditional transportation and supply chain as well as blockchain network-based transportation and supply chain. This work pointed out the problems faced by the supply chain industries by using the traditional transportation and supply chain as well as the solutions to the problems that provide the blockchain network-based transportation and supply chain in those industries.

The blockchain network observed that it could overcome the issues faced by traditional methods and make the system more efficient and trustworthy. Consumer and supplier can monitor all delivery updates in the explorer while checking hashes in the system and by a block explorer matching.

This work can help the industry people to know the benefits of blockchain network-based transportation and supply chain and try to implement in real life to get better and efficient results. This technology can majorly be used in all small-scale supply chain and can be easily implemented at very low cost.

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